Time-Accurate Turbine Engine Simulation in a Parallel Computing Environment Part II - Software Alpha Test

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Integrated Modeling and Test Environments (IMT)

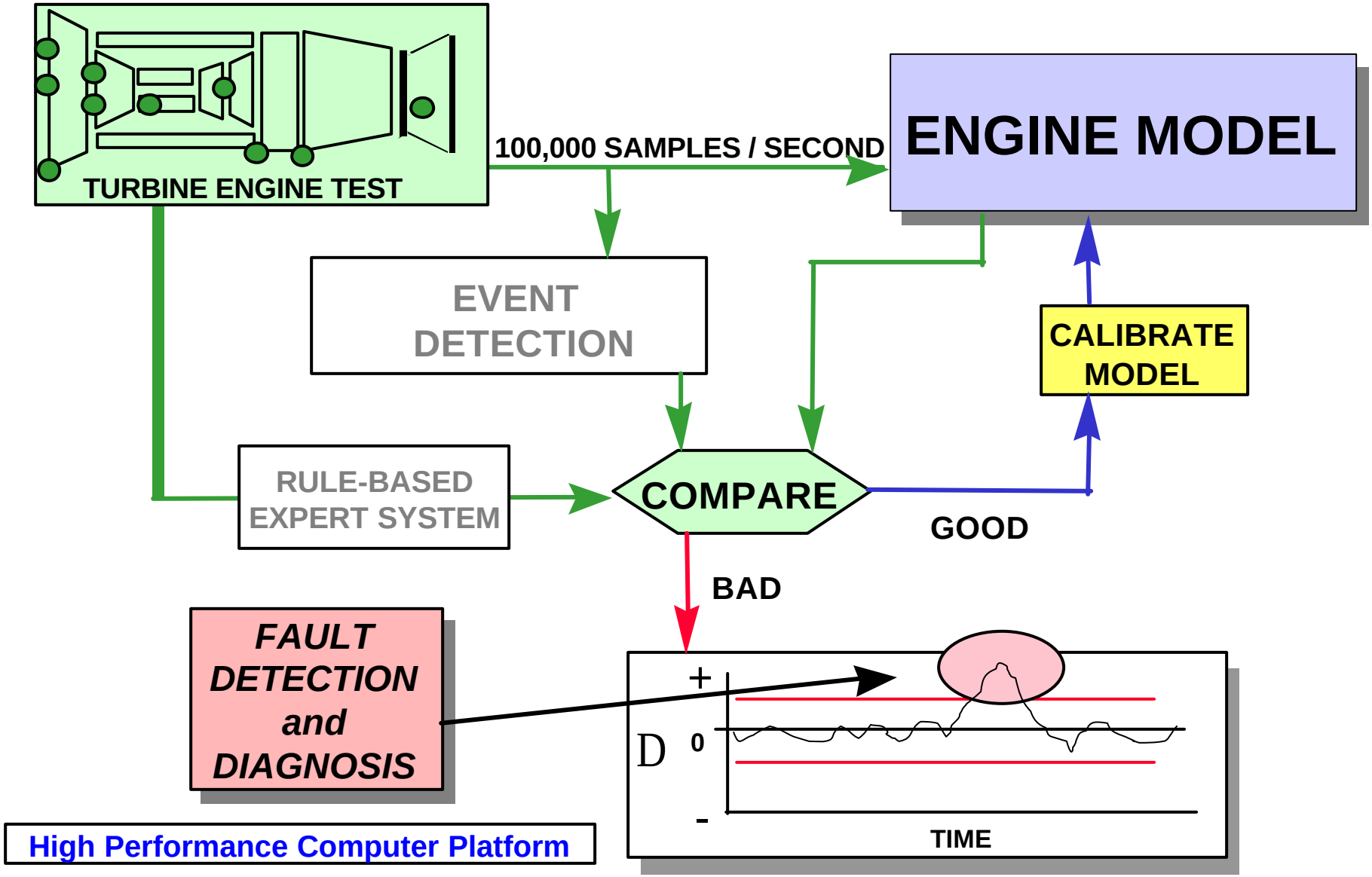
HPCMO Users Group Conference 2001
June 19-21, 2001

OUTLINE

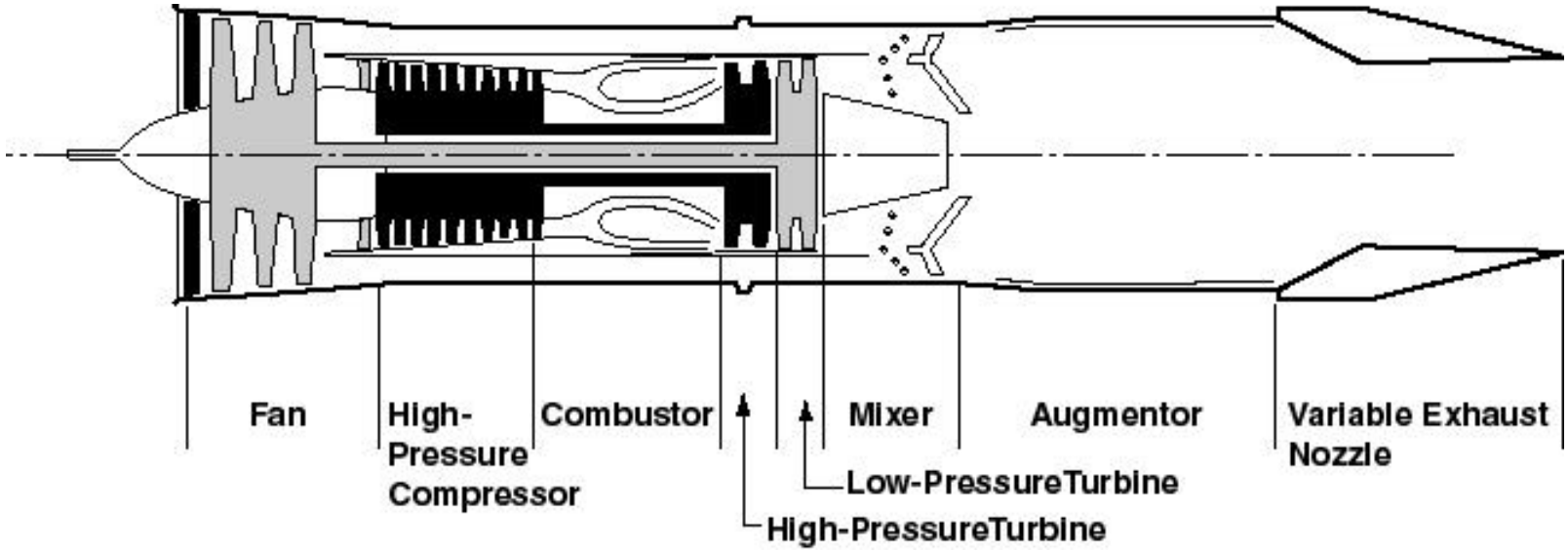
- **Introduction**
  - **Code objective: *Model-Based Test Data Validation***
  - **Engine and Model Description**
  - **SAT* Results**
- **Code Enhancements**
- **Alpha-Test Results**
  - **Contrasted to SAT**
  - **Overall Performance**
- **Summary and Impact**

*SAT – Software Acceptance Test

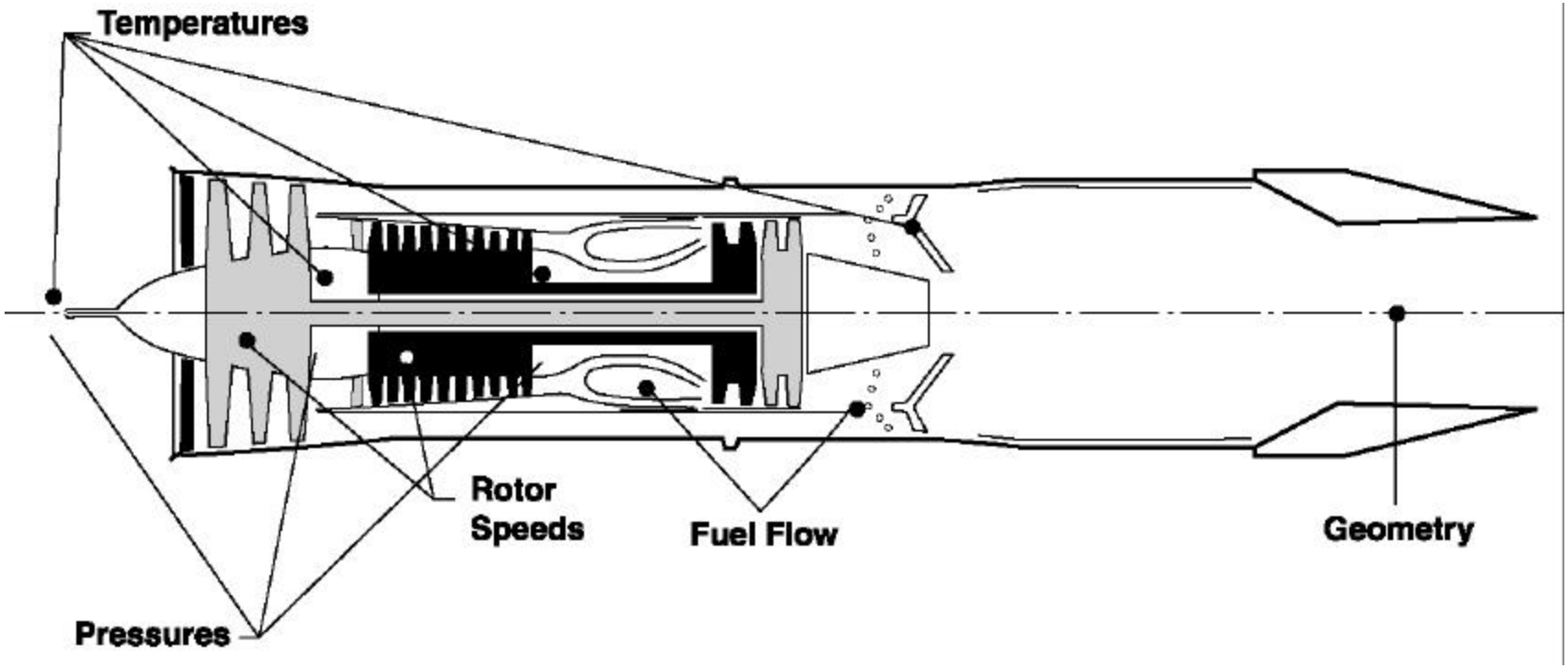
Real-Time Model-Based Data Validation System



Augmented Turbofan Engine: Model Components

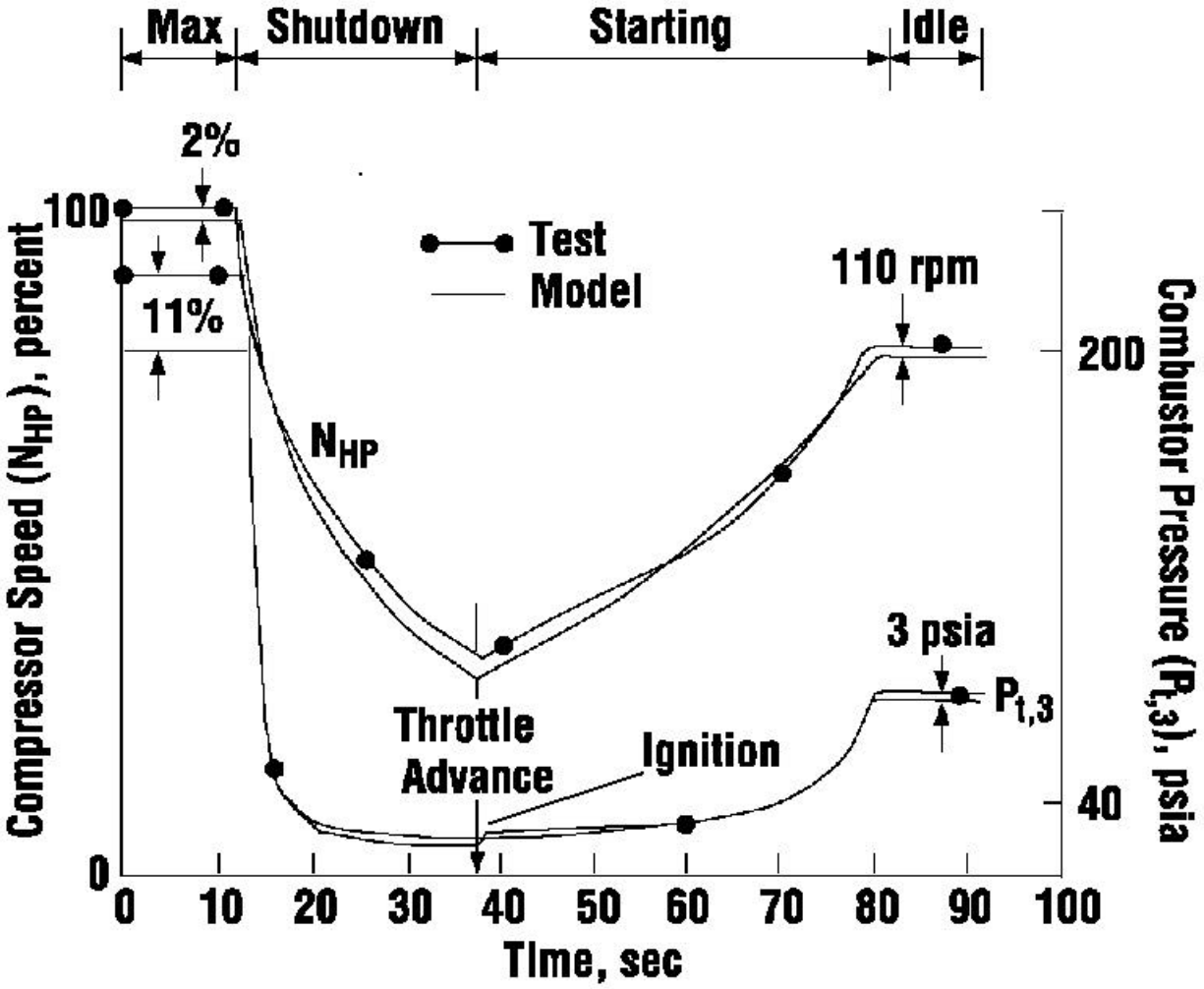


Test Measurements Used as Inputs to Model



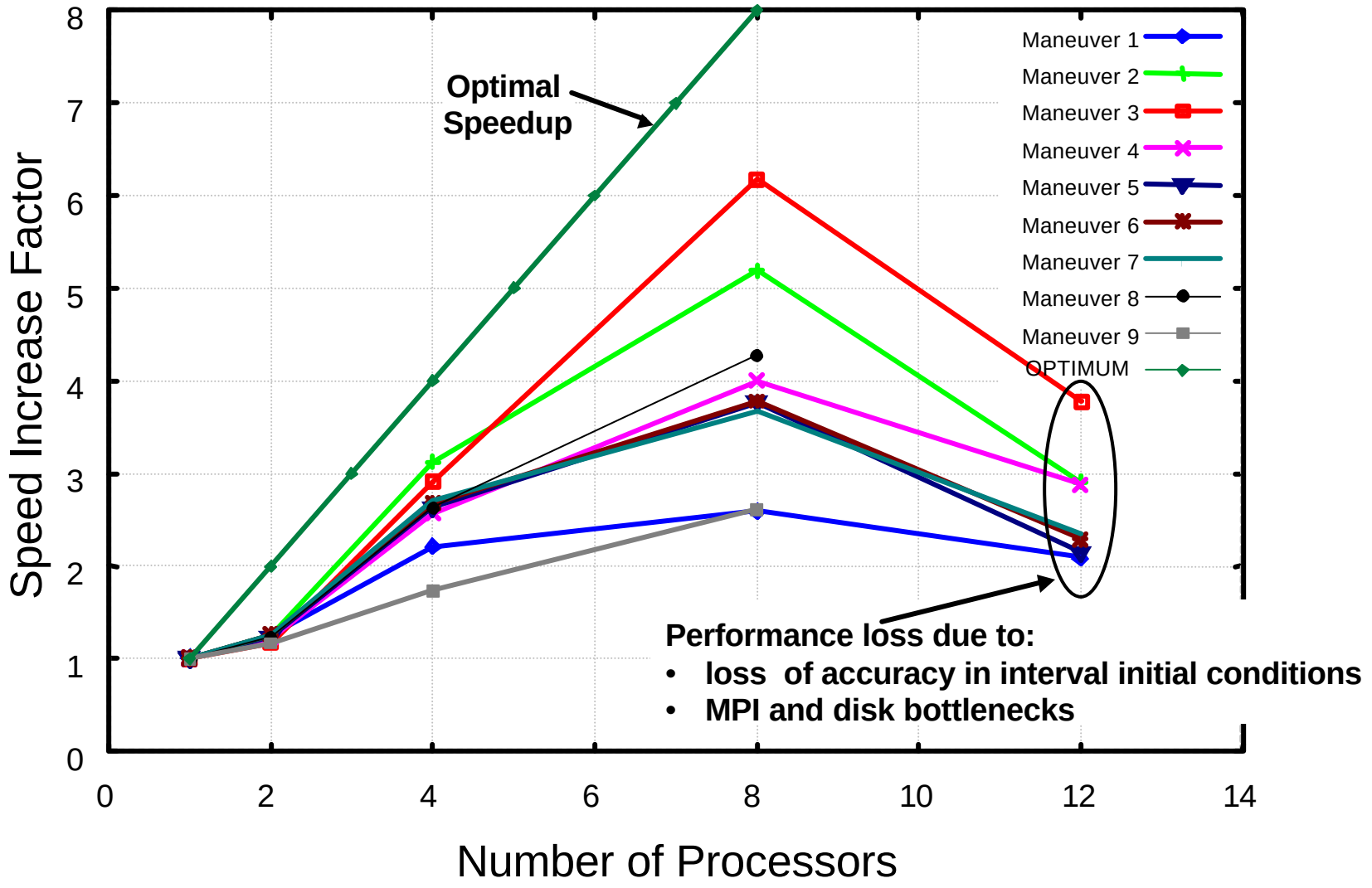
Model Fidelity

Comparison of Model Calculations to Test Measurements



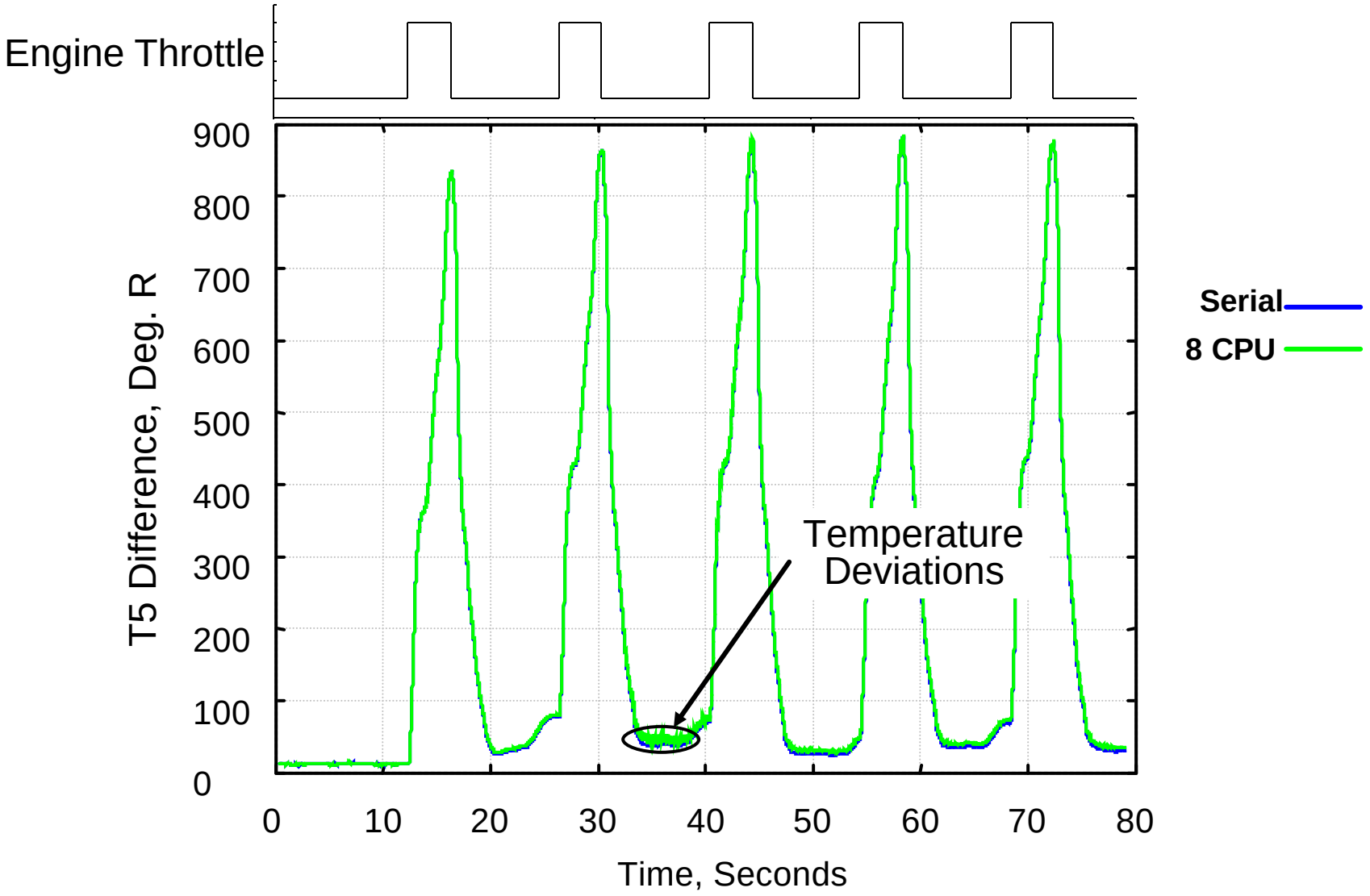
SAT Results

Execution Speed Increase with Number of Processors



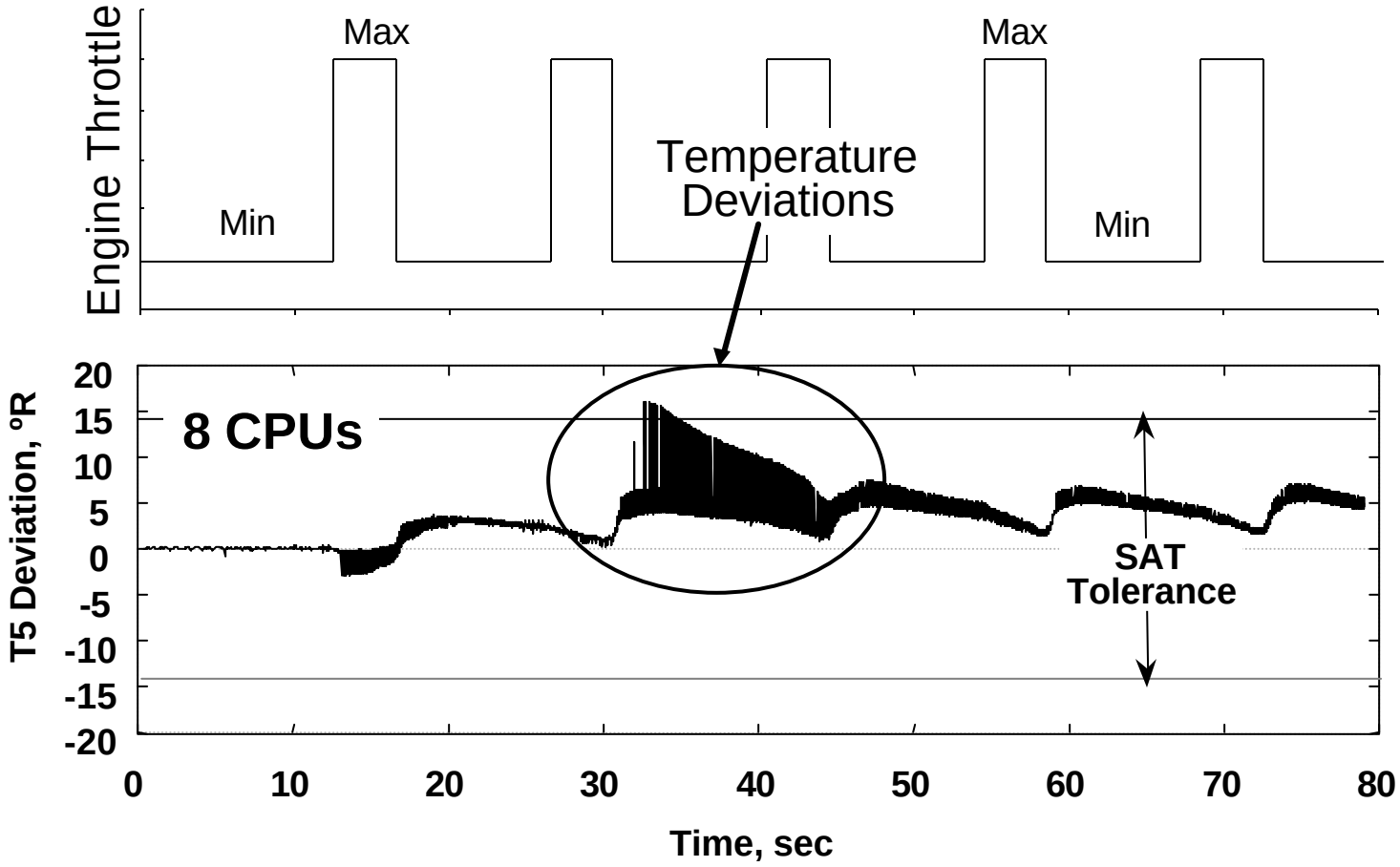
SAT Results

Solution Repeatability: Comparison of Serial and Parallel Results (T5)



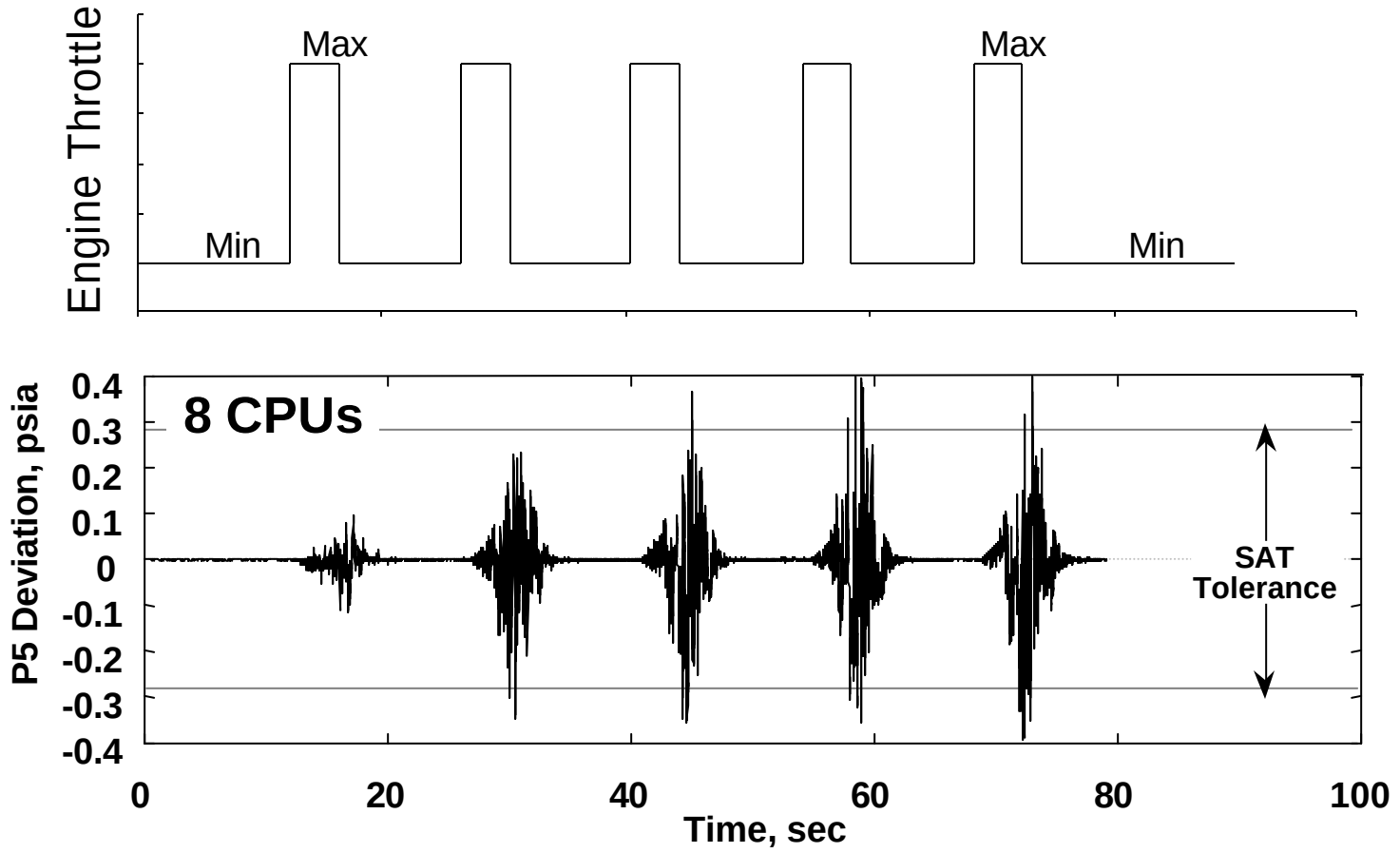
SAT Results

Deviations Between Serial and Parallel Solutions (T5)



SAT Results

Deviations Between Serial and Parallel Solutions (P5)



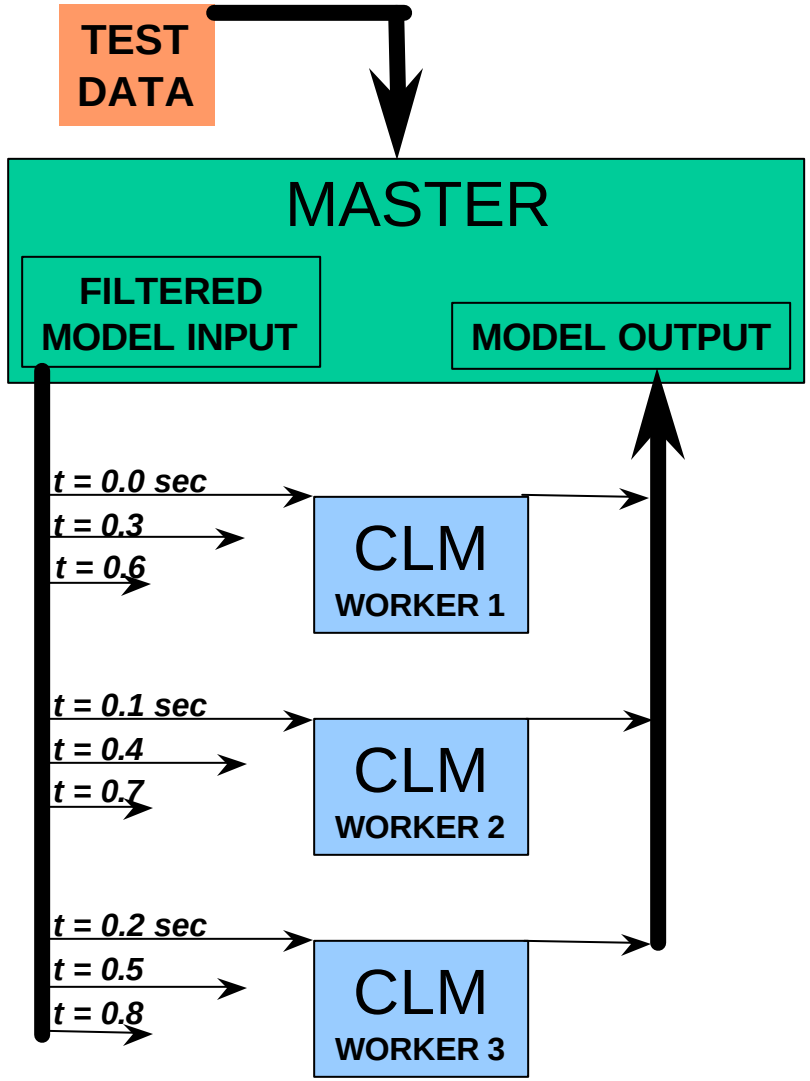
Code Enhancements

- **Reduce Communication Bottleneck**
  - **Send grouped intervals of samples not single samples**
- **Improve solution repeatability**
  - **Establish “coarse-grain” worker to provide approximate boundary conditions (thermal and rotor dynamics) for each data interval**
- **Eliminate hard disk access bottleneck**
  - **Read data into memory before execution to eliminate mass storage bandwidth issues**

SAT Approach

Time-Decomposition of CLM Using Replicated-Workers

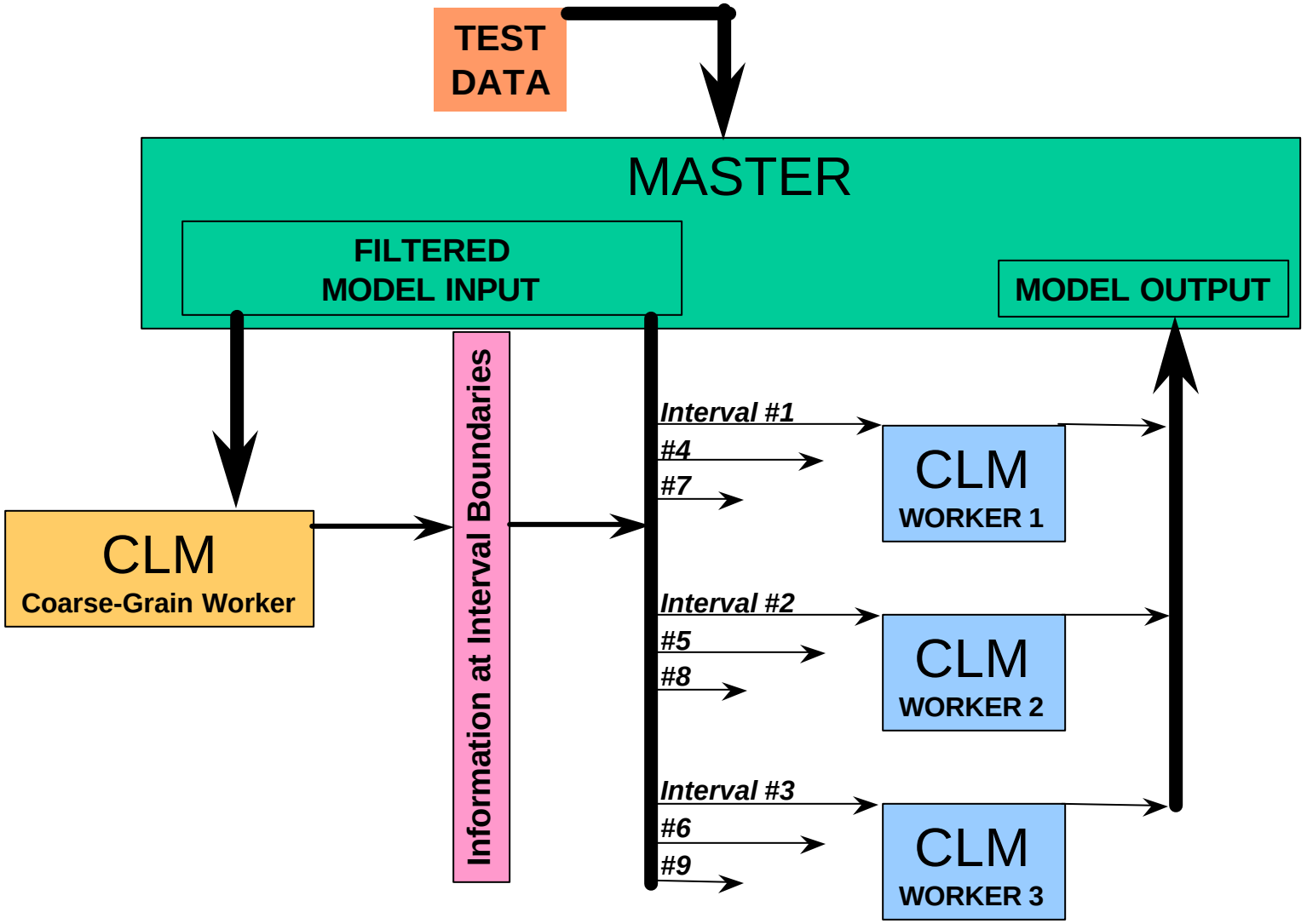
(Sample-by-Sample Decomposition)



Alpha Approach

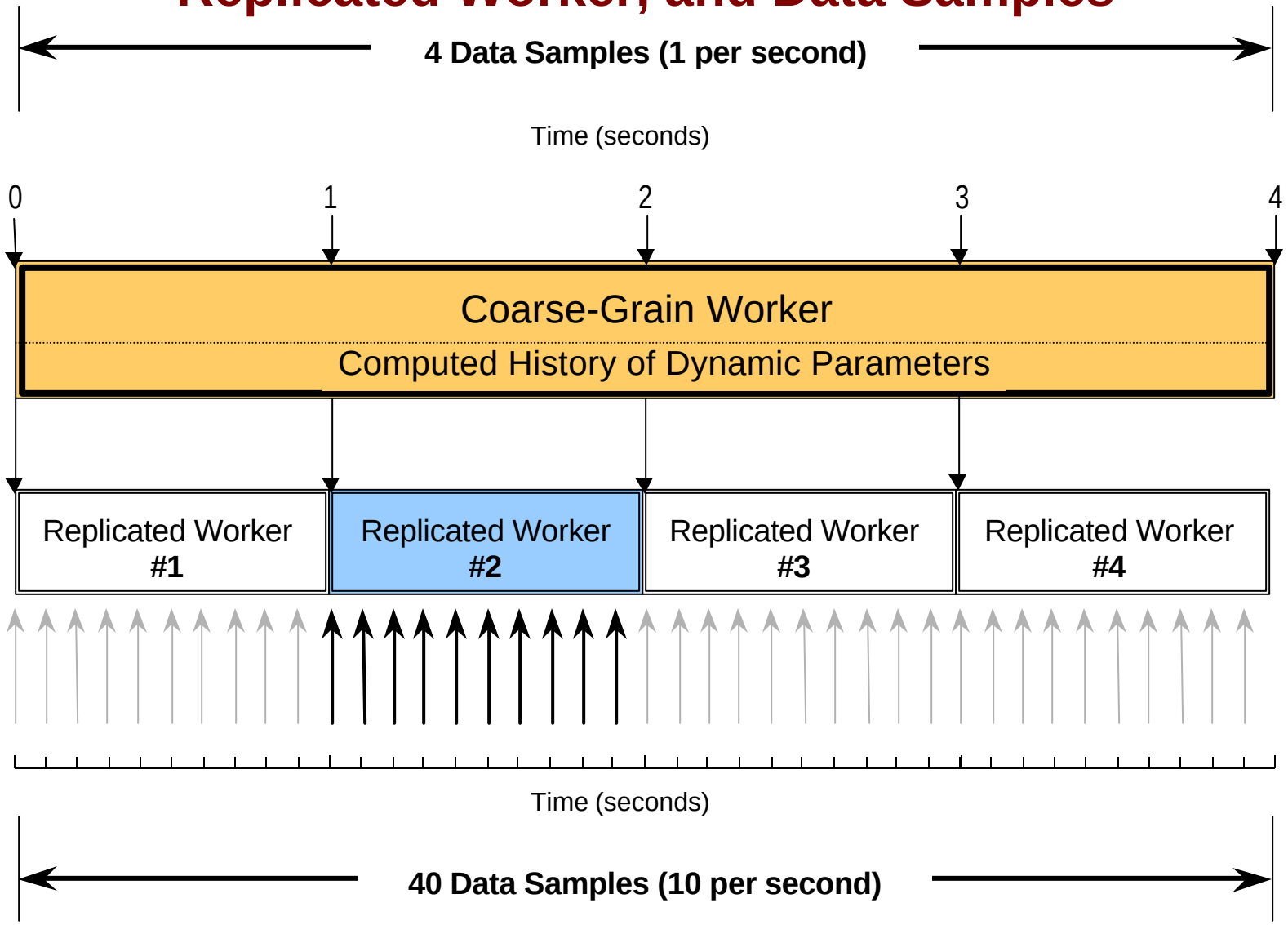
Time-Decomposition of CLM Using Replicated-Workers

(Grouped Samples "Interval" Decomposition)



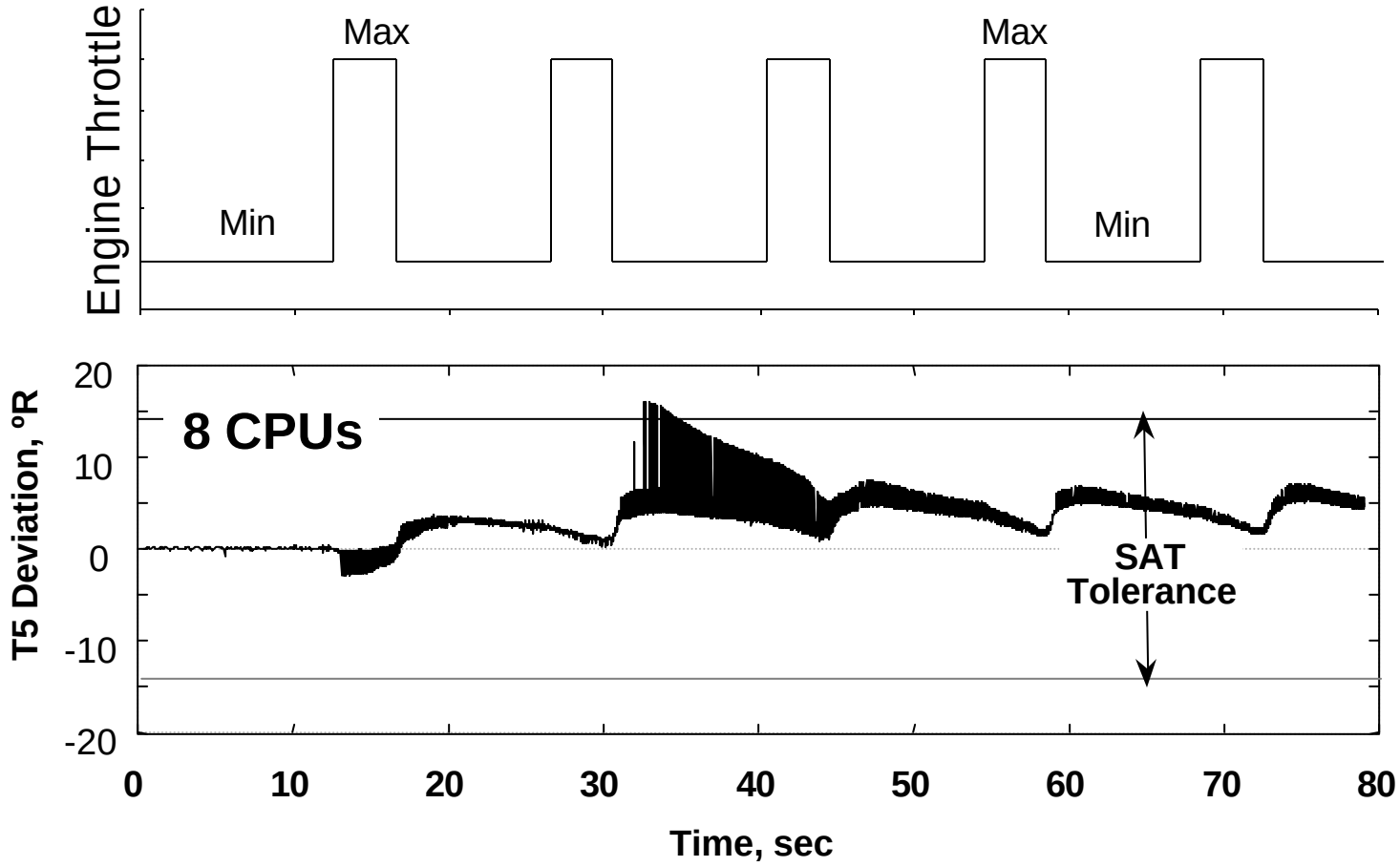
Alpha Approach

Relationship Between Coarse-Grain Worker, Replicated Worker, and Data Samples



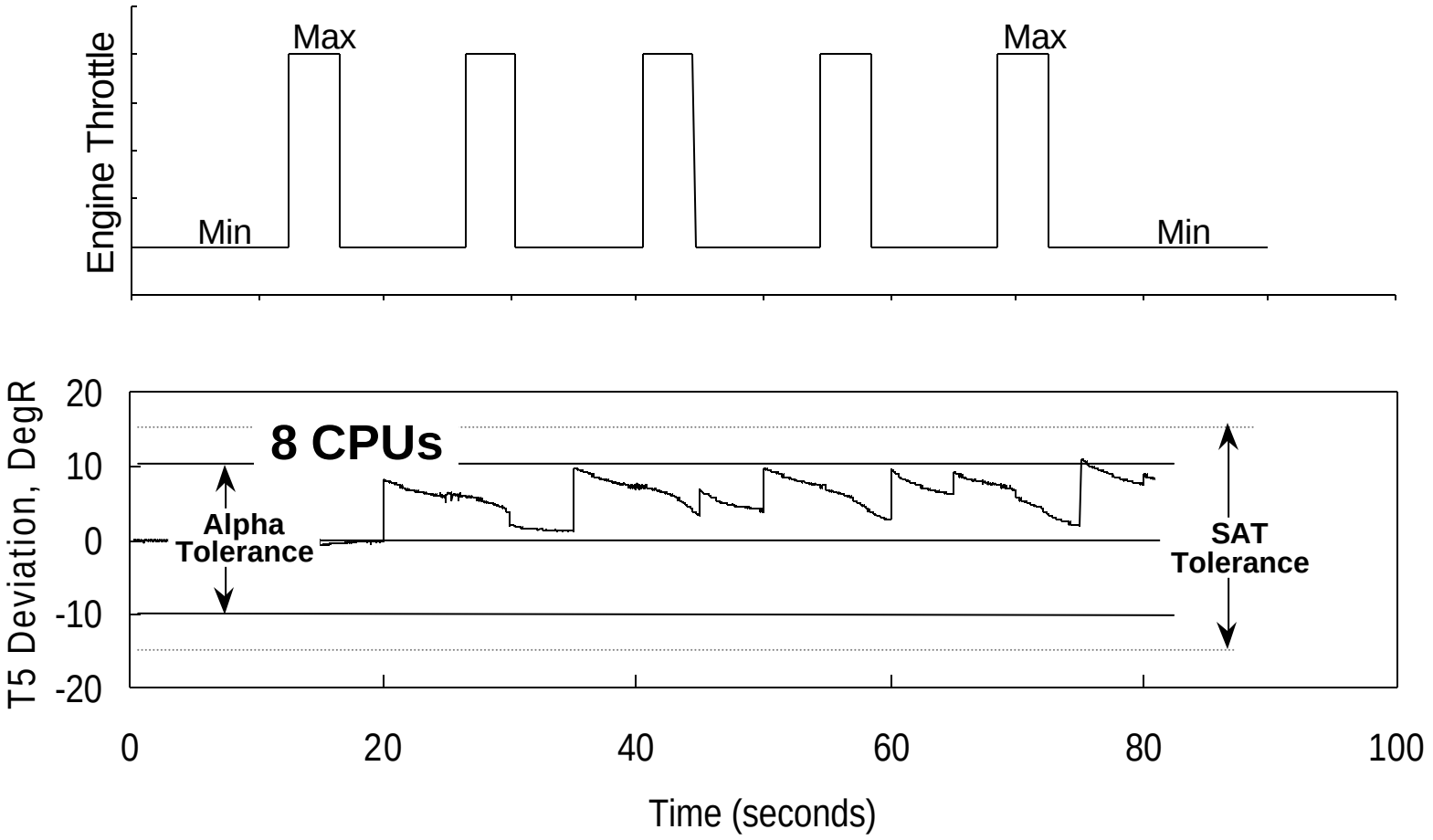
SAT Results

Deviations Between Serial and Parallel Solutions (T5)



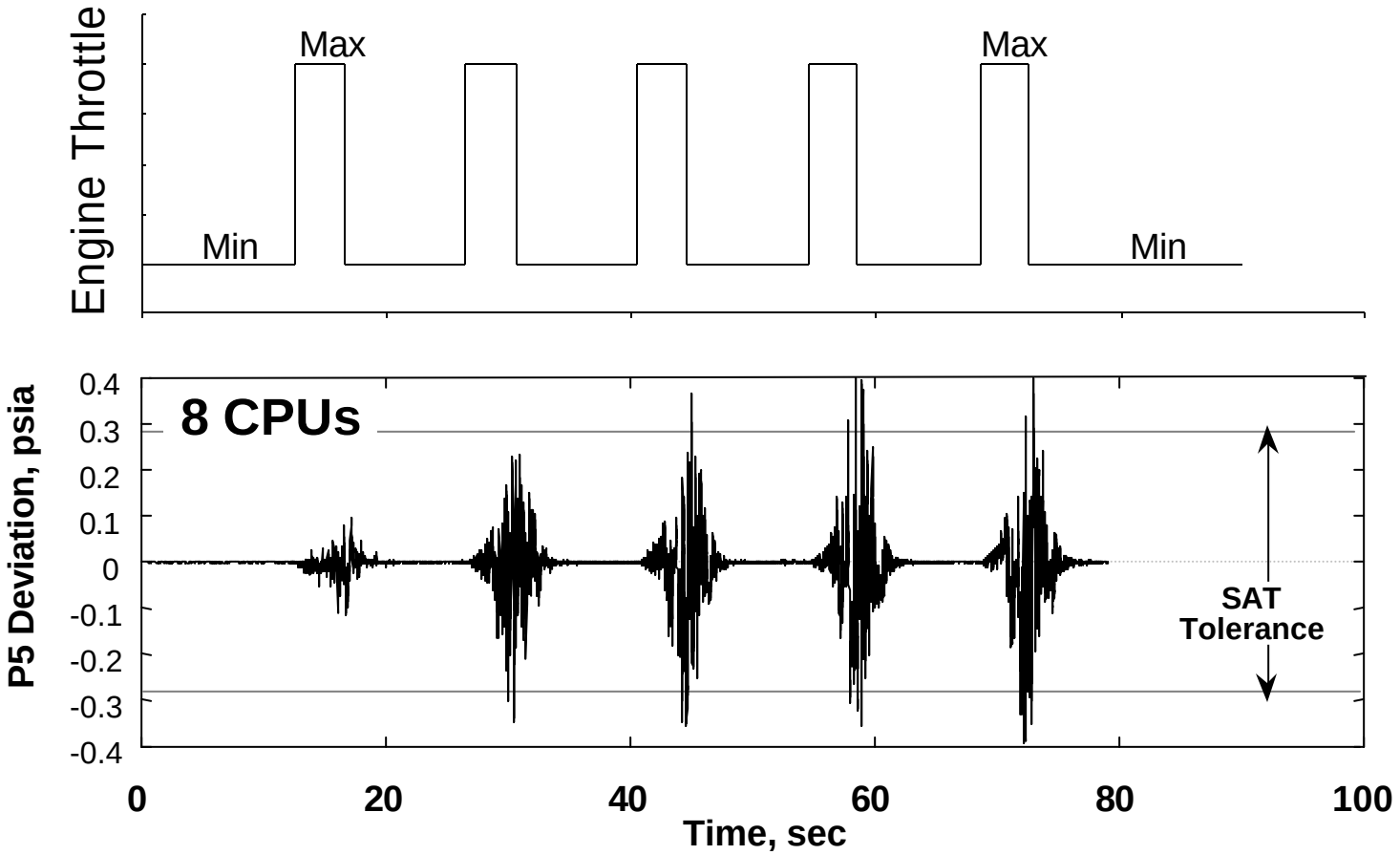
Alpha Test Results

Deviations Between Serial and Parallel Solutions (T5)



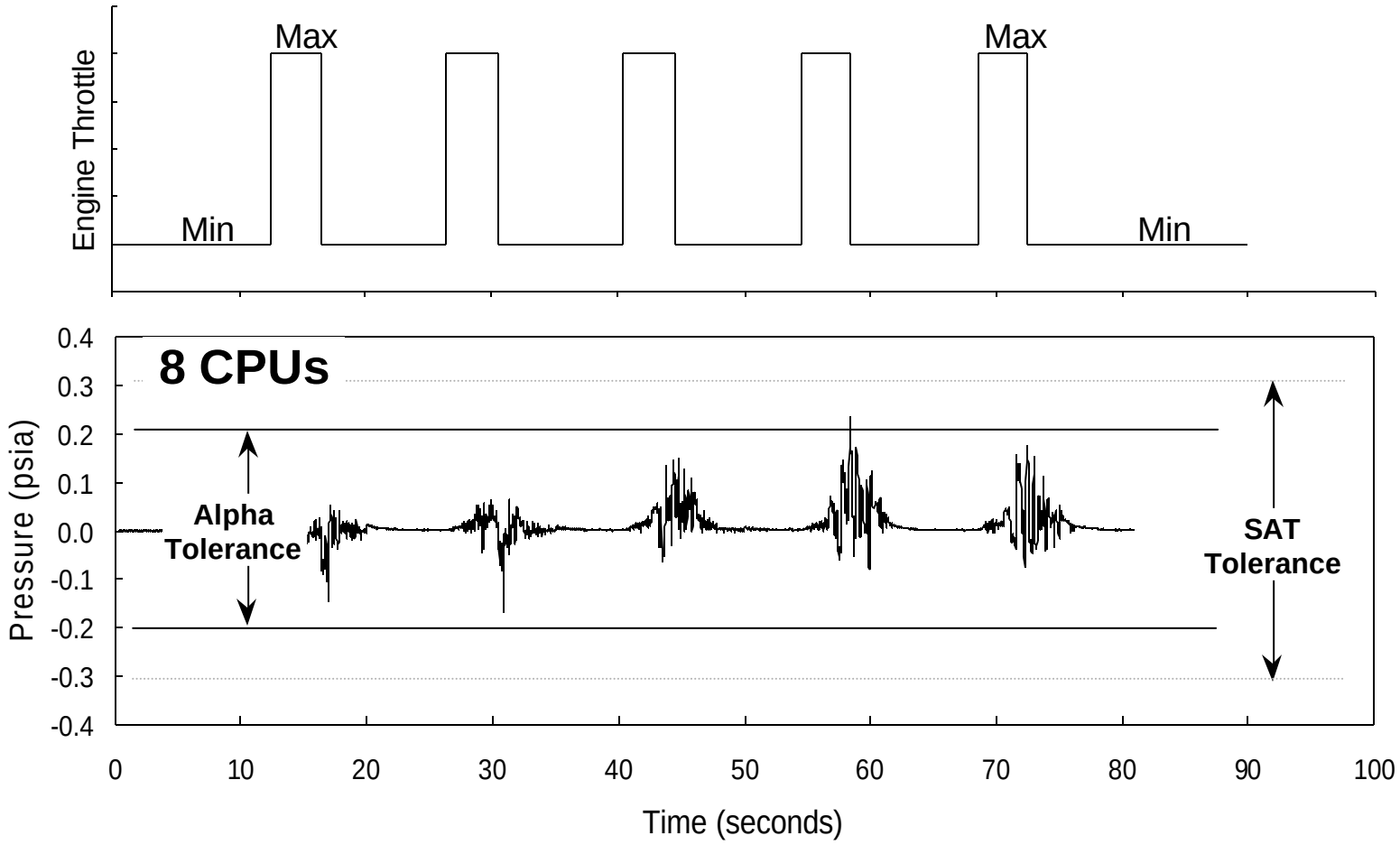
SAT Results

Deviations Between Serial and Parallel Solutions (P5)



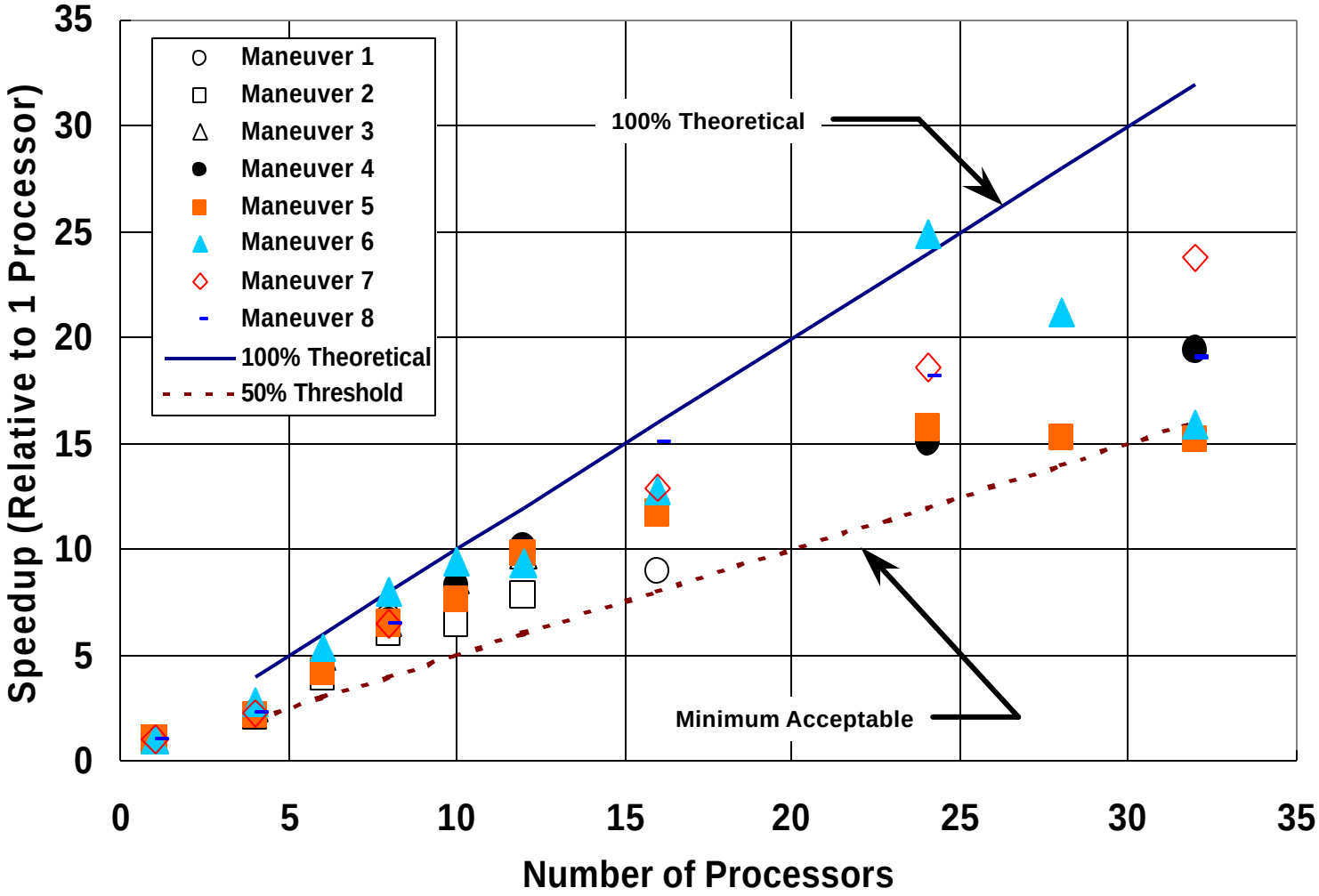
Alpha Test Results

Deviations Between Serial and Parallel Solutions (P5)



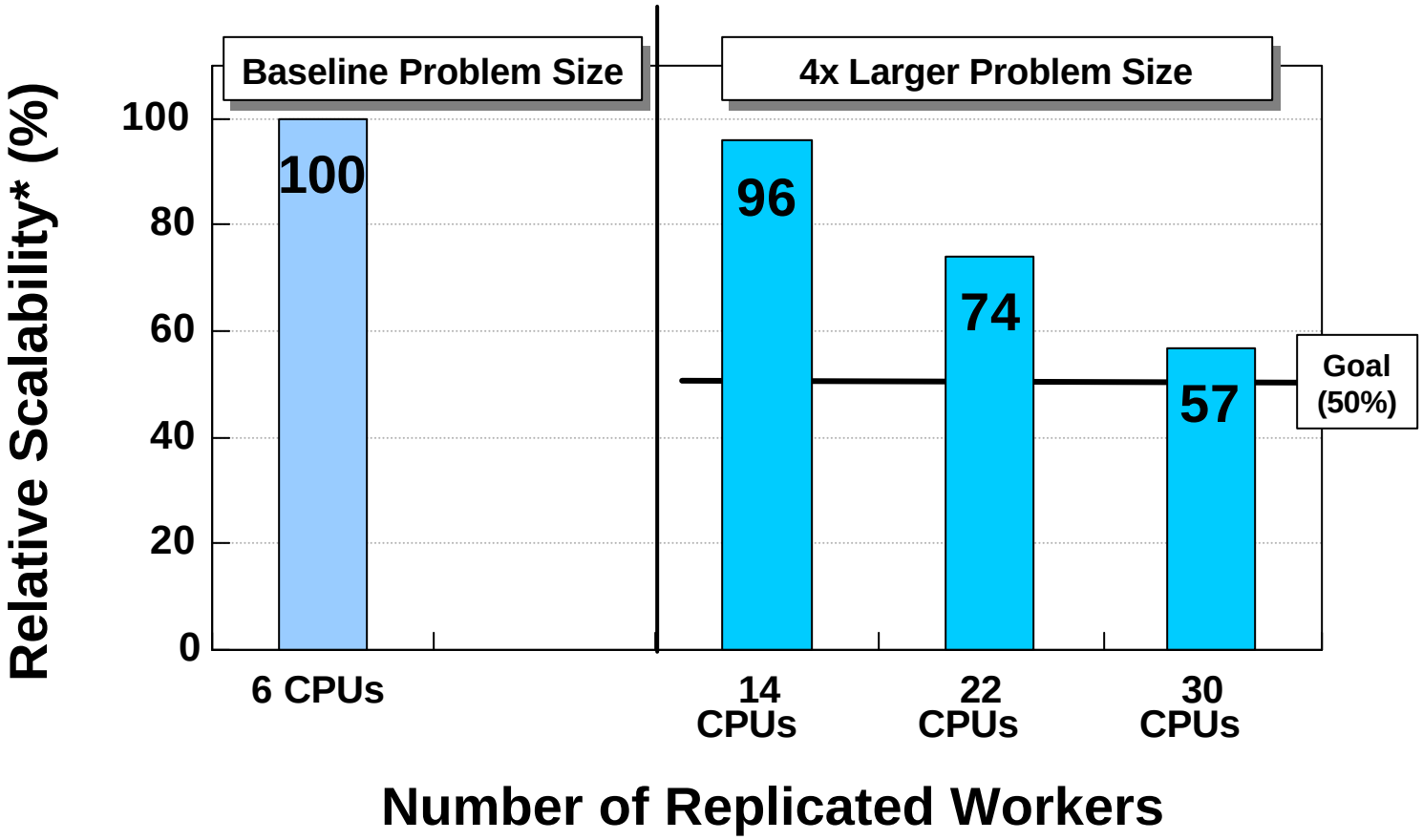
Alpha Test Results

Overall Performance: Execution SpeedUp Exceeds Acceptance Criterion



Alpha Test Results

Overall Performance: Scalability Exceeds Goal



**Average processing rate per CPU relative to Baseline*

SUMMARY

- **Exceeded Alpha Test Requirements**
  (>50% of Max Theoretical)
  - **Speedup**
  - **Scalability**

- **Improved solution repeatability**
  - **Interval decomposition**
  - **Computed conditions at interval boundaries**

IMPACT

- **Time-Accurate Parallel Model Enables:**
  - **Real-time operation (and faster)**
  - **Higher fidelity engine simulation potential**